The Biological Status in Bonnie Creek, Galum Creek, and White Walnut Creek Following Stream Diversion and Reconstruction

Prepared for:
Peabody Energy

Prepared by:
ENVIRON International Corporation
Denver, Colorado

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EXECUTIVE SUMMARY

Comparisons of the fish and benthic macroinvertebrate communities from reconstructed portions of Bonnie Creek, Galum Creek, and White Walnut Creek (Perry County, Illinois) were compared to benthic and fish samples from upstream undisturbed sites in each stream, and a selected non-impacted stream site from Eagle Creek Basin surveyed by IEPA (Matson and Hite 1988). Existing data generated for Bonnie Creek, Galum Creek and White Walnut Creek was obtained from field surveys required as conditions of permits granted to Consolidation Coal Company (Perry County, IL) for diversion and subsequent permanent relocation of portions of these streams in the late 1980's up through 2000. All streams are first or second order small streams from geographical regions that currently include agricultural land uses and previously coal mining activities. The purpose of the comparisons were to determine the status of the biological communities in the reconstructed portions of each stream and assess whether the reconstruction stream reaches supported benthic and fish communities that were equivalent to site pre-relocation or regional reference stream conditions. A regional reference site typical of relatively undisturbed conditions situated within only an agricultural land use watershed could not be found with IEPA data for both fish and macroinvertebrate sufficient for comparison. The reference site within the Eagle Creek Basin is considered conservative for comparison to sites within an agricultural setting as IEPA classified this reference site as non-impacted.

The fish community evaluation was based on the fish IBI following Simon and Dufour (1998) using abundance based data from the sites. The macroinvertebrate community evaluation included comparison of the EPT richness and total richness metrics for spatial and temporal patterns because some of the available data was not abundance data and presented as species presence/absence data. In addition, the macroinvertebrate Index of Biotic Integrity (MIBI) following Plafkin et al. (1989) was used for available abundance data to assess overall status among sites.

Evaluation of the fish data indicated the assemblage at all stream sites exhibited species common to small streams of Illinois. The streams were characterized by a dominance of green, bluegill, and longear sunfish, along with frequent capture of red shiner and sand shiner (Bonnie Creek) and/or blackstripe and bluntnose minnow (Galum Creek and White Walnut Creek). A fish IBI evaluation could not be conducted for White Walnut Creek because presence/absence data only was available. Fish IBI values for all streams evaluated, including the reference stream, were in the low range of values and indicated communities dominated by tolerant species that were primarily omnivores and capable of exploiting a variety of physical habitats.

The benthic macroinvertebrate assemblage at all sites included species common to small streams in Illinois and represented most of the major groups of aquatic insects as well as snails, aquatic isopods and amphipods, flat worms, mussels and clams. The overall abundance of benthic macroinvertebrate organisms in the samples collected was lower than expected at all sites in each stream and the entire sample was likely evaluated to obtain the available data. Confounding factors at the time of sample collection included lack of measureable flow at many sites. However, low specimen counts were common to all sites and collection dates and are not considered a significant factor in interpretation of results. The richness-based metrics for all stream sites were highly variable and comparisons indicated a general, but not conclusive, trend for higher EPT richness in April samples compared to samples collected in August. In contrast,

the total richness metric showed a general, but not conclusive, trend for higher richness in August than present in April.

Key findings from the evaluation of fish and benthic macroinvertebrate samples from reconstructed portions of streams with comparison to upstream or regional reference conditions included:

1. Fish IBI values for Galum Creek indicate the reconstructed reach to support a fish community typical of a relatively undisturbed stream within Illinois, and difference in fish IBI value among the undisturbed upstream reach and the reconstructed site was not of sufficient magnitude to indicate a meaningful spatial difference in fish community health or integrity.

2. Fish IBI values for Bonnie Creek in 1997 indicated fish community health and integrity in the reconstructed reach was equivalent to the fish community health and integrity of the undisturbed upstream site BCA. The comparison to Bonnie Creek fish IBI results would also indicate the reconstructed reach of Bonnie Creek supports a fish community typical of a relatively undisturbed stream within Illinois. Bonnie Creek is a tributary of Galum Creek.

3. The benthic macroinvertebrate samples from Galum Creek collected during in August indicates the reconstructed reach attained a macroinvertebrate community equivalent with pre-construction conditions (based on MIBI values) and the Galum Creek macroinvertebrate assemblage was equivalent to the regional reference site. The data indicated recovery of the macroinvertebrate community in Galum Creek occurred within a 5-year time span.

4. Macroinvertebrate samples collected from the reconstructed portion of Bonnie Creek in 1997 were considered equivalent to the upstream benthic community. The benthic macroinvertebrate MIBI values from Bonnie Creek were less than determined for the regional reference site suggesting lower biological integrity. However, based on the relatively consistent results for total richness and EPT richness at both the undisturbed and relocated sites in Bonnie Creek, an MIBI score lower than the regional reference site may be normal for Bonnie Creek.

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1 Introduction

The purpose of this study is to report on the evaluation of fish and macroinvertebrate community recovery following diversion and permanent relocation. The study involved three different permanently relocated streams located in Perry County, Illinois, USA, each of which had available fish and macroinvertebrate data from a relocated stream reach and undisturbed upstream reach. A determination of recovery was based on comparisons of the biological community structure and composition between the relocated stream reach and upstream undisturbed reach, as well as comparison to a regional reference stream. The regional reference stream was selected to represent a site with fish and macroinvertebrate data that was located within a coal mining region of Illinois and was considered undisturbed based on Illinois Environmental Protection Agency (IEPA) biomonitoring results. The goal of this study was to demonstrate recovery of the biological communities within the relocated stream reaches to be structurally equivalent with upstream conditions and/or comparable to an appropriate regional reference condition.

This evaluation used existing data generated for Bonnie Creek, Galum Creek and White Walnut Creek from field surveys required by permits granted to Consolidation Coal Company (Perry County, IL) for diversion and subsequent permanent relocation of portions of these streams in the late 1980's up through 2000. Galum Creek benthic macroinvertebrate assemblage and fish census data were available for 1988 (Pike and Owen 1988), 1993 (Pike and Owen 1993), 1997 (Owen and Pike 1998), 2003 (PEC 2003) and 2006 (PEC 2006). Bonnie Creek benthic macroinvertebrate assemblage and fish survey data were available for 1997 (Owen and Pike 19998), 2003 (PEC 2003), and 2006 (PEC 2006). Benthic macroinvertebrate assemblage and fish survey data were available for White Walnut Creek in 2003 (PEC 2003). Each of these streams is located in Perry County, IL and can be associated with potential impacts from coal mining.

The regional reference stream reflecting minimal impact was selected from among several watershed studies reported by the Illinois Environmental Protection Agency (IEPA). The selected stream site was chosen from the Intensive Survey of the Eagle Creek Basin, Saline and Gallatin Counties, Illinois (Matson and Hite 1987). The Eagle Creek Basin is in extreme southeast Illinois and represents a small second order Illinois stream with minimal reported impacts from mining or significant anthropological activities. This Eagle Creek Basin area and watershed was selected because, like Perry County, historical active or inactive coal mine operations were known to occur within the watershed and that IEPA had conducted intensive surveys of streams within watershed. Biological survey data from site ATE-06 in the Eagle Creek Basin was specifically targeted for comparison to Galum Creek, Bonnie Creek, and White Walnut Creek primarily because the watershed drainage size for this site best matched the drainage area for the relocated stream reaches. A comparable watershed drainage size among all the streams evaluated facilitates a comparison of the fish census data, and likely subjects the biotic communities to similar hydrological patterns. Conveniently, results of the IEPA intensive survey for site ATE-06 also indicated to IEPA that this site likely representative of background conditions for the Eagle Creek Basin Watershed area by exhibiting none of the traditional mining related impacts. The ATE-06 site was characterized by low metals, sulfate, chloride and cyanide concentrations and IEPA stated this site to have no indications of other major water quality impacts (Matson and Hite 1987).

2 Methods

The general approach of this project was to compare standard bioassessment results for sites within the relocated stream reached from Bonnie Creek, Galum Creek, and White Walnut Creek, to bioassessment results for undisturbed sites upstream of the relocated stream reaches, and to bioassessment results for site ATE-06 in the Eagle Creek Basin. Detailed specifics regarding field sample collection efforts, sorting, taxonomic classification and enumeration protocols, and development of metric values and metrics scores were not always sufficient to rely on a direct comparison of conclusions presented in each report.

Bioassessment protocols and the choice of metrics have progressed and improved over the 13-year period of study for the various streams reflected in the monitoring reports, and a direct comparison of bioassessment indices would likely not be based on equivalent measures and result in misleading conclusions. Thus, recalculation of bioassessment metrics and indices using a suite of community composition metrics common to all samples was necessary to alleviate potential problems associated with comparisons of survey results based on a mix of different bioassessment measures or techniques. The recalculation of bioassessment metrics and indices used in this study included generally accepted methods with considerations given to the taxonomic precision of the available data.

Fish bioassessment protocols followed protocols presented in Simon and Dufour (1998) for the Eastern Corn Belt Plain of Indiana applicable to fish survey data from streams with >20 square miles drainage area and less than 1,000 square miles. Assumptions that were made to address certain metric scoring criteria in lieu of missing information included an equal sampling efficiency (catch per unit effort) for all stations and no deformities, eroded fins, lesions, and tumors (DELTS) for all fish captured. Benthic macroinvertebrate bioassessment protocols followed Protocol III of Plafkin et al. (1989) with comparison to the Eagle Creek Basin site ATE-06 as the reference community. It was assumed that similar methods and adequate sampling effort was conducted among all the sites evaluated.

3 Results

3.1 Fish

3.1.1 Galum Creek Fish

Galum Creek fish surveys were conducted at sites GLA (upstream), GLC (relocated reach), and GLD (downstream) during April and August of 1988, 1993, 1997, 2003 and 2006, with the exception of survey dates during May of 1993 and September of 2006. Only presence/absence data were recorded (no enumeration data) for the 2003 and 2006 surveys. Site GLC from 1988 to 1997, and sites GLC2, GLC3 and GLC4 in 2003 and 2006 represented the diversion and relocated portion of Galum Creek. Site GLA was an undisturbed site upstream from the diversion, and site GLD was downstream of the reconstructed stream reach. Flow in Galum Creek was variable from year to year but patterns that existed indicated higher flows in spring than in fall (often no flow in August at the sampling sites) and flow showed a trend to increase from GLA downstream to GLD. Maximum flow during the sampling periods in spring was 30.7 cubic feet per second (cfs) with median flow around 12 cfs compared to a maximum flow of 3 cfs in the fall with the median flow, when present, at 1 cfs or less. Conductivity ranged from 395 to 4868 umhos/cm, and was generally lower during April than during August when flow existed at sites during both sampling periods. The fish assemblage for the three sites were dominated by bluegill sunfish, green sunfish, and longear sunfish, with bluntnose minnows being characteristic at the upstream GLA site; blackstripe topminnow being more common at GLC than other sites; and shiners, especially the red shiner (*Cyprinella*) being characteristic at the downstream site GLD. Flow conditions likely influenced habitat conditions and the presence or absence of species during sampling events.

3.1.2 Bonnie Creek Fish

Bonnie Creek fish surveys that provided abundance data included sites BCA (upstream), BCC (relocated stream reach), and BCD (downstream) during April and August of 1997. Survey results provided presence/absence data only in 2003 and 2006 for sites BCB2, BCB3 and BCB4 that represented the relocated reach of Bonnie Creek; site BCA represented the undisturbed upstream site; and BCD and BG represented undisturbed downstream locations. Flow at the time of the 1997 survey was less than 20 cfs and was higher in April than reported during August (zero flow reported at BCA and BCC). The fish assemblage at all three sites was dominated by shiners (red shiner and sand shiner) and sunfish (green sunfish, bluegill sunfish, and longear sunfish). The upstream site (BCA) exhibited a more diverse and evenly distributed array of sunfish than either of the two downstream sites (BCC and BCD) and a high abundance of the bluntnose minnow, which was rare or absent at the downstream sites. A total of 15 different fish species were reported from Bonnie Creek in 1997 compared to a total of 25 different fish species present in 2006 indicating a increase in the number of resident species in this stream. Within the reconstructed reach the fish species increased from 10 species in 1997 to 18 different species in 2006.

3.1.3 White Walnut Creek

White Walnut Creek fish surveys were conducted at sites WWA (upstream), WWC2 (relocated reach), and WWD (downstream)) in April and August of 2003. Flow at the time of the surveys were extremely low and ranged from zero or too low to measure during August to 0.84 cfs upstream increasing downstream to 3.4 cfs at WWD. Fish data were reported as

present/absent data only and a total of 17 different species were listed for White Walnut Creek. Three species (golden shiner, green sunfish, and bluegill) were present at the upstream site WWA while 11 different fish species were reported from the reconstructed reach WWC2, and 10 different fish species were reported from the downstream site WWD. The fish assemblage at WWC2 and WWD included several sunfish, shiners, and minnows. Species only observed at the reconstructed site WWC2 included spotted bass, redear sunfish, orange spotted sunfish, and bluntnose minnow. Species observed only at WWD included the gizzard shad, sand shiner, and tadpole madtom.

3.1.4 Eagle Creek Basin Site ATE-06

The Eagle Creek Basin fish survey was conducted on May 28-29, 1986 by IEPA. Site ATE-06 is located in Upper Eagle Creek and at the time of the fish survey flow was noted to be low. Flow conditions at ATE-06 were presumed to be comparable to the relative flow conditions at the reconstructed stream reaches during fish survey events. A total of seven different fish were collected from site ATE-06 of which four was represented by sunfish species. However, the grass pickerel (*Esox americanus vermiculatus*) was the most abundant fish captured.

3.2 Fish IBI

Fish IBI values could be calculated for Bonnie Creek in 1997 data, Galum Creek for 1988, 1993, and 1997 data, and the selected reference site ATE-06 in the Eagle Creek Basin for the 1986 data. Fish IBI results for Bonnie Creek in 2003 and 2006; Galum Creek for 2003 and 2006, and White Walnut Creek for 2003 cannot be determined because of the presence/absence type of data presented for each stream. Fish community health and quality increases with IBI value. Evaluation of the fish IBI values will focus on relative differences and patterns between the reconstructed reach of the stream to the undisturbed upstream site (seasonal and spatial); comparisons IBI value with the reference site ATE-06 and considered not to be impacted by mining and other land uses; and for Galum Creek the change in IBI value over the multiple-year monitoring period (temporal trends). Fish IBI metric values, metric scores, and the calculated fish IBI value following Simon and Dufour (1998) at site ATE-06, and sites in Bonnie Creek and Galum Creek for April is presented in Table 1, and for August samples in Table 2.

3.2.1 Galum Creek Fish IBI

The fish IBI values for Galum Creek ranged from a low of 22 during August of 1993 at the undisturbed upstream site GLA to a high of 38 at the downstream site GLC during August of 1997. However, fish IBI values at all three monitoring sites were generally the lower during August 1993 and generally higher during August of 1997. No consistent pattern could be identified that indicated a seasonal trend for generally higher or lower fish IBI values during either April or August. Fish IBI values for site GLC within the reconstructed reach of Galum Creek tended to be slightly lower than the undisturbed upstream IBI values from GLA, but this was not consistent. For example, Table 1 shows fish IBI values from GLC were higher than upstream at GLC during April of 1998 (value of 30 and 24, respectively) and equal at a value of 22 during August 1993 (Table 2). Fish IBI values at the downstream site GLD were typically greater than fish IBI values in the reconstructed reach (GLC) at all times. The difference in fish IBI value among the three sites was not of sufficient magnitude to indicate a meaningful spatial difference in fish community health or integrity in Galum Creek. Similarly, a temporal pattern could not be identified that indicated a consistent trend of increasing or decreasing fish IBI value

over the nine-year monitoring period at any of the three sites. However, on a temporal basis the fish IBI values during the nine-year monitoring period indicate the fish community within the reconstructed reach to be equivalent to the undisturbed upstream location. For example, the fish IBI value at site GLC in the reconstructed reach was higher in May 1993, April 1997 (Table 1), and August of 1997 (Table 2) than calculated for undisturbed upstream site GLA during previous fish survey events. The fish IBI results show the fish community within the reconstructed reach of Galum Creek has supported a fish community of equal health and integrity as the undisturbed upstream reach since 1988. Furthermore, the fish IBI values for the downstream reach were similar and suggest any stream reconstruction and relocation activities had negligible effect on downstream fish communities.

The findings of a comparison of the fish IBI results for Galum Creek to the fish IBI status of the regional reference site ATE-06 in the Eagle Creek Basin indicate slightly higher IBI scores for Galum Creek during both April and August. Based on IBI scores the fish community within reconstructed reach of Galum Creek is comparable to a fish community typical of a relatively undisturbed stream within Illinois. Confounding factors associated with the recalculation of the fish IBI data and evaluation of the fish IBI results includes uncertainty if a comparable level of effort and methods were used during sampling efforts from both streams, and the relative flow conditions at the time of each survey event.

3.2.2 Bonnie Creek Fish IBI

The Bonnie Creek 1997 fish IBI values for April (Table 1) were slightly higher than IBI values determined for August (Table 2) at each of the upstream, reconstructed reach, and downstream monitoring sites. The decrease in IBI value from spring to late summer was minimal and within a range of values that indicated no meaningful change in health and integrity of the fish community. In April, the IBI value for the upstream site BCA was 32 compared to a value of 30 for site BCC in the reconstructed reach; and in August the IBI values were 26 and 28 for sites BCA and BCC, respectively. The downstream site BCD has the lowest IBI value of 27 for the April survey (Table 1) compared to the same value of 28 as the reconstructed reach during August (Table 2). No spatial pattern among the sites was consistent for both the April and August sample events. In addition, the difference in IBI value among the sites was not of sufficient magnitude to indicate a meaningful difference in fish community health among the sites during either April or August. The 1997 fish IBI data indicates that the fish community health and integrity in the reconstructed reach of Bonnie Creek was equivalent to the fish community health and integrity found upstream at the undisturbed BCA site.

The Bonnie Creek fish IBI values for 1997 ranged from 26 to 32 and were higher at all three monitoring sites than the fish IBI value of 24 calculated for the fish survey data from ATE-06 in the Eagle River Basin. Based on the conclusion by Matson and Hite (1987) that site ATE-06 is generally not impacted by regional mining activities and local land use, the low fish IBI results for ATE-06 may indicate typical results for a small Illinois stream. The comparison to Bonnie Creek fish IBI results would also indicate the reconstructed reach of Bonnie Creek supports a fish community typical of a relatively undisturbed stream within Illinois. Confounding factors associated with the evaluation of the fish IBI data includes uncertainty whether a comparable level of effort and method (shock time, double pass, block nets) was used during all sampling

efforts, flow conditions at the time of sampling, and the time span of eleven years between survey events from ATE-06 and Bonnie Creek.

3.3 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected coincident with fish survey events at Galum Creek, Bonnie Creek, and White Walnut Creek. Macroinvertebrate samples from ATE-06 in the Eagle Creek Basin were collected on October 20 and 22, 1986. Thus, a comparison to the August sampling from the reconstructed stream reaches is most appropriate considering the developmental life stages and size of benthic organisms susceptible for capture. Flow conditions in Upper Eagle Creek were described as dry with the exception of one extensive pool area at the time of sample collection (Matson and Hite 1987), which likely mimicked the zero to near zero flow conditions in the reconstructed streams in August and September when benthos samples were collected. Sample collection methods were assumed to be equivalent among all sampled streams and incorporated a D-net kick sample and subsequent picking of organisms from sampled rocks, net, and debris (Galum, Bonnie, and White Walnut Creek's) or use of a standard 30-mesh screen or D-net with subsequent picking of organisms at ATE-06. Following collection, samples were preserved and transported to an analytical laboratory for species identification and enumeration. Replicate samples were not discussed and did not appear to be collected from any site.

The combined assemblage of benthic organisms reported from the reconstructed stream samples represented various snails, aquatic isopods and amphipods, flat worms, mussels and clams, as well as the major groups of aquatic insects common to most of the central United States. Sample total abundance was variable and for the late summer collections in the reconstructed streams often resulted in samples with less than 100 specimens; below the typical guideline of a minimum 100 specimens and a target of 300 specimens for determining a benthic index of biotic integrity. With the exception of the August 1988 sample from GLD in Galum Creek (dominated by chironomid flies) and two other samples of 124 and 159 organisms, all other samples contained less than 100 specimens. The late summer benthic collections (August or September) contained a higher abundance of organisms than the spring (April or May) collections, an expected pattern that can be attributed to life stage development and larger body sizes for the benthic community in general. Similarly, total taxonomic richness (number of different taxa in the sample) was generally higher in the late summer collections than reported for the spring samples. Macroinvertebrate richness was variable from season to season and from year to year depending upon the stream. Macroinvertebrate richness in Bonnie Creek and Galum Creek tended to decreased downstream in both the summer and fall collections prior to 2003.

Specific to the objective of this evaluation is the status and response of the biological communities in the reconstructed reaches of Bonnie Creek, Galum Creek and White Walnut Creek. Evaluation of spatial and temporal trends is a useful approach for identifying biological patterns and responses. Spatial trends for the reconstructed portions of the streams can be identified by the repeated occurrence of patterns observed for comparisons of the biological data from undisturbed sites with the reconstructed reach. The undisturbed upstream sample site would be the primary target for comparison since the undisturbed downstream sample site may have been influenced by stream reconstruction activities. Temporal trends for the

reconstructed portions of the stream can be identified by a evaluation of year-to-year changes in biological patterns within the reconstructed reach, which can also be compared to similar year-to-year changes for the undisturbed upstream sample site.

Spatial and temporal pattern recognition for the entire period of monitoring in Bonnie Creek and Galum Creek were limited by presence/absence data reported for monitoring results in 2003 and 2006. Macroinvertebrate community metrics that provided the most information with respect to implications for community health and structure that incorporated presence/absence data included total taxonomic richness and EPT (Ephemeroptera, Plecoptera and Trichoptera) richness. Total taxonomic richness has implications to diversity and stability of the community and EPT richness has implications to water quality conditions as these organisms as a group are generally considered sensitive to a variety of pollutants. Higher EPT richness and total richness values are typically interpreted as an indicator of more favorable stream conditions that can include better water quality, a more diverse physical habitat and stable hydrologic patterns. EPT richness and total richness values for Bonnie Creek, Galum Creek, and White Walnut Creek sample events are presented in Table 3.

The temporal biological response to reconstruction of the stream channel will focus on identifying trends or patterns in the macroinvertebrate IBI (MIBI) when possible, and patterns for EPT richness and total richness that increase and are indicative of favorable stream conditions. The implications of increasing MIBI, EPT richness, and total richness values over time can suggest improved water quality conditions, stability of the physical characteristics of the channel, and development of a balanced biotic community. Progression towards stable physical characteristics and the development of a balanced biotic community is a natural process in newly formed streams.

3.3.1 Galum Creek Macroinvertebrate Richness

Galum Creek macroinvertebrate data indicated EPT richness to be low at all sites surveyed that suggested a complex benthic community was likely not present. In general, there was some seasonal variation in EPT richness at all sites with the lowest EPT richness values often observed during the August sample periods (Table 3). For example, the average EPT richness at the undisturbed upstream GLA site for the 1988, 1993, 1997, 2003 and 2006 sampling periods was 4 species during April compared to an average of 2 species in August. EPT richness was often lower within the reconstructed reach that observed at the undisturbed upstream site, but this pattern was not consistent. For example, average EPT richness in the reconstructed stream reach of Galum Creek for the same sampling period was lower (1 species in April) but equivalent to the upstream GLA site in August with an average of 2 species. Considering the low values for EPT richness in Galum Creek (Table 3), these differences between seasons and sites are negligible and can be accounted for by sample collection and sample analysis variability.

Total species richness was also considered low and variable; exhibited an inconsistent seasonal trend for lower total richness values for the August samples; and similar to EPT richness generally indicated a complex benthic community was not present. During the April monitoring period total richness averaged 12 species at the undisturbed upstream site compared to an average of 8 species in the reconstructed reach of Galum Creek, but showed little difference in

average total richness for the August samples (Table 3). Average total richness for the August samples was 14 species for both the upstream GLA site and the reconstructed reach of Galum Creek. The maximum total richness value at the upstream GLA site for any given sample period was 19 species and comparable to the maximum of 18 species for the reconstructed reach of Galum Creek. Similar to the EPT richness, the observed spatial differences in total richness values were not of sufficient magnitude to be considered meaningful and likely could be accounted for by variability in sample collection and sample analysis.

Galum Creek data includes five sampling periods spanning 18 years. The strongest temporal pattern includes an overall increase in total richness for samples collected in April in the reconstructed reach (GLC) and the undisturbed upstream GLA site. Total richness during April increased from 3 to 17 species in the reconstructed reach of Galum Creek over the 1988 to 2006 monitoring period, but the increase in richness primarily occurred after 2003 (Table 3). The downstream total richness data indicated that until 2006, richness in the relocated portion of Galum Creek was suppressed during April compared the rest of the stream system. In contrast, during August the EPT richness and total richness values from the relocated reach were similar to the undisturbed upstream and downstream sites over the entire 18-year monitoring period (Table 3). Based on macroinvertebrate richness data alone samples from the relocated reach of Galum Creek were equivalent with samples from the undisturbed upstream site and downstream site as early as August 1998.

The available Galum Creek data includes a 9-year time span from 1988 to 1997 when species abundance values were recorded prior to presence/absence data reporting in 2003 and 2006. Subjecting the 1988, 1993, and 1997 macroinvertebrate abundance data to the IBI protocols of Plafkin et al. (1988) calculation of the MIBI incorporates additional community metrics other than richness-based metrics and allows another evaluation of trends that includes functional aspects of the assemblages. Higher MIBI values indicate better healthy biotic communities and imply higher quality habitat and water conditions and MIBI results for Galum Creek are presented below in Section 3.4.

3.3.2 Bonnie Creek Macroinvertebrates

In general the Bonnie Creek EPT richness and total richness values were low and variable, and indicated a complex macroinvertebrate community was likely not present in Bonnie Creek. A spatial comparison of total richness and EPT richness values from the reconstructed reach with the upstream undisturbed site (BCA) indicated a general pattern of lower richness values in the reconstructed reach during April. This was most apparent for the EPT richness metric, which also exhibited lower richness values for the August monitoring period (Table 3). For example, the average EPT richness at BCA during the April monitoring period for 1997, 2003 and 2006 was 5 species compared to an average EPT richness of 2 species for the August samples from BCA. For the same time periods average EPT richness from the reconstructed reach was 4 species in April and 2 species for the August samples. The maximum EPT richness for the April samples was 5 species at both the upstream site and reconstructed reach in April 2006.

Bonnie Creek total richness values for the reconstructed reach compared to the undisturbed upstream site showed a pattern similar to EPT richness, but less apparent. Average total richness for 1997, 2003 and 2006 at BCA was 13 species for both the April and August

sampling periods, compared to mean total richness values of 11 species (April) and 12 species (August) from the reconstructed stream reach. The variability in total richness and EPT richness that occurred from sampling period to sampling period at the upstream site was typically mirrored at the reconstruction stream reach (Table 3). Differences in the EPT richness and total richness values among sites and sample periods were considered negligible relative to the overall level of species richness reported for the Bonnie Creek samples.

Temporal patterns in the reconstructed portion of Bonnie Creek were also not well established. The strongest pattern was best demonstrated by a relatively stable increase in total richness value from 12, to 11, to 16 species exhibited by the August samples collected in 1997, 2003, and 2006 (Table 3). However, there is an overall pattern of reduced richness in the macroinvertebrate communities for the 2003 samples that curtail the presence of a progressive trend. This same pattern for richness values in 2003 is present in samples collected from Galum Creek suggesting a widespread meteorological or hydrologic event may have occurred. The minor increases of only 1 or 2 species in value for EPT richness and total richness between 1997 and 2006 in the reconstructed portion of Bonnie Creek may be attributed to sampling and analysis variability and are of insufficient magnitude to be meaningful. Based on macroinvertebrate richness data the monitoring results indicate the macroinvertebrate community from the relocated reach of Bonnie Creek was equivalent with the macroinvertebrate community from an undisturbed upstream site.

3.3.3 White Walnut Creek Macroinvertebrates

Evaluation of spatial patterns in White Walnut Creek was based on the April and August sampling periods in 2003. EPT richness was higher in April than observed in August at all sites, and found to be equivalent between the reconstructed reach and the undisturbed upstream site (Table 3). EPT richness at both the upstream and reconstructed reach sites was 5 species in April 2003. Total richness was also higher in April than observed in August and observed to be higher in the relocated reach of Bonnie Creek than for the undisturbed site upstream during both sampling periods. The higher EPT richness and total richness values in the reconstructed portion of White Walnut Creek indicates benthic community conditions equivalent or better than occur upstream, but may also reflect successful colonization by a large suite of organisms within new available habitats. Intense colonization commonly occurs in new stream habitats and elevated richness values are frequently observed during initial monitoring events. Elevated richness values indicating intense colonization were not as apparent during the initial monitoring events of 1997 in Bonnie Creek or during 1988 in Galum Creek (Table 3).

Temporal trends in White Walnut Creek cannot be ascertained because only one year of presence/absence macroinvertebrate monitoring data is available.

3.4 Macroinvertebrate IBI

The macroinvertebrate IBI (MIBI) based on Plafkin et al. (1988) included benthic organism abundance data from site ATE-06 collected in October 1986 in the Eagle Creek Basin (Matson and Hite 1987) as a reference location and for comparison to organism abundance data from Bonnie Creek (1997) and Galum Creek (1988, 1993, and 1997) for samples collected in April or May (spring) and August or September (late summer). MIBI results for Bonnie Creek in 2003 and 2006; Galum Creek for 2003 and 2006, and White Walnut Creek for 2003 cannot be

determined because of the presence/absence type of data presented. Results will focus on a comparison of the MIBI score from site ATE-06 to MIBI scores for the reconstructed reaches of Bonnie Creek and Galum Creek. An IBI score of less that 83% of the reference condition is interpreted as indication of less biological integrity (Plafkin et al. 1988). Macroinvertebrate IBI (MIBI) metric values, metric scores, and MIBI value for site ATE-06, and sites in Bonnie Creek and Galum Creek are presented for April sample collections in Table 4 and for August sample collections in Table 5.

3.4.1 Galum Creek MIBI

MIBI results for samples collected from the reconstructed reach in Galum Creek during spring and late summer of 1988, 1993, and 1997 showed seasonal differences when compared to the reference site macroinvertebrate assemblage. During spring, the MIBI values from the reconstructed reach of Galum Creek were 18, 36, and 26 for 1988, 1992, and 1997, respectively, (Table 4) indicating that only in spring of 1993 the macroinvertebrate assemblage was equivalent with the reference site ATE-06 conditions (85.7%). The MIBI results also indicated the upstream undisturbed site supported macroinvertebrate communities were equivalent to the reference condition only in spring of 1997 (also 85.7%). However, because of the expected seasonal difference in life stage of aquatic insects within streams the comparison of the April Galum Creek samples to the October ATE-06 samples may not be entirely reliable. The MIBI results for the late summer macroinvertebrate collections are likely a more appropriate and reliable comparison to the October ATE-06 reference samples. MIBI results for the late summer samples for 1988, 1992, and 1997 (Table 5) from the reconstructed reach in Galum Creek were 36, 38, and 40, or 85.7% and considered equivalent with the reference at ATE-06. The August results include conditions in 1988 when the MIBI value for the undisturbed upstream site in Galum Creek was not equivalent to the reference condition (66.7% of ATE-06).

The results of the August MIBI for Galum Creek indicates the relocated reach supported a macroinvertebrate community equivalent with the undisturbed upstream reach and equivalent with a regional reference site considered minimally impacted by mining activities (Table 4). Furthermore, the results of the MIBI evaluation suggest the recovery of the macroinvertebrate community in Galum Creek occurred within a 5-year time span and continued to improve. Confounding factors with respect to conclusions regarding the reference site include seasonal variation as demonstrated by comparisons to the regional reference site using the April Galum Creek macroinvertebrate collections.

3.4.2 Bonnie Creek MIBI

MIBI results for samples collected from the undisturbed upstream portion of Bonnie Creek in 1997 were 94% (Table 4) and 85% (Table 5) of the MIBI results of the regional reference MIBI score of 42 at the ATE-06 site. This comparison demonstrated Bonnie Creek was equivalent with a typical small stream in Illinois. Within the reconstructed portion of Bonnie Creek, the MIBI value was 34 for both April (Table 4) and August (Table 5) sample events. The MIBI data for the reconstructed portion of Bonnie Creek for both April and August 1997 monitoring periods was 81% of the regional reference site ATE-06, but nearly identical to the undisturbed upstream reach in Bonnie Creek. These data indicate the benthic community from the relocated reach in Bonnie Creek recovered to a level that was equivalent with undisturbed reaches upstream of the reconstruction zone. It is possible that the normal condition of the Bonnie Creek benthic

community exhibits an MIBI value more typical of agriculture influences and related land use practices or hydrologic patterns.

4 Conclusions

The fish and benthic macroinvertebrate communities from reconstructed and relocated portions of Bonnie Creek, Galum Creek, and White Walnut Creek (Perry County, Illinois) were compared to benthic and fish samples from upstream undisturbed sites from each stream, and a selected non-impacted regional Illinois stream site from Eagle Creek Basin surveyed by IEPA (Matson and Hite 1988). All study streams are first or second order small streams from geographical regions with current agricultural land uses and previously supported coal mining. The non-impacted regional reference stream selected for comparison is conservative as localized agricultural land use and impacts are minimal. The purpose of the comparison was to determine the status of the biological communities in the reconstructed and relocated portions of each stream and assess whether the reconstruction stream reaches supported benthic and fish communities that were equivalent to normal stream or regional reference conditions.

The fish community evaluation was based on the fish IBI following Simon and Dufour (1998) using abundance based data from the sites. The macroinvertebrate community evaluation included comparison of the EPT richness and total richness metrics for spatial and temporal patterns because some of the available data was not abundance data and presented as species presence/absence data. In addition, the macroinvertebrate Index of Biotic Integrity (MIBI) following Plafkin et al. (1989) was used for available abundance data to assess overall status among sites.

The fish assemblage at all streams and sites evaluated exhibited species common to small streams of Illinois. The streams were characterized by a dominance of green, bluegill, and longear sunfish, along with frequent capture of red shiner and sand shiner (Bonnie Creek) and/or blackstripe and bluntnose minnow (Galum Creek and White Walnut Creek). A fish IBI evaluation could not be conducted for White Walnut Creek because only species presence/absence data were available. Conclusions based on the result of this evaluation of the fish community survey data include the following:

- Fish IBI values for all streams evaluated, including the reference stream, were in the low range of possible values and indicated communities dominated by tolerant species that were primarily omnivores and capable of exploiting a variety of physical habitats.
- Fish IBI values for Galum Creek indicate the reconstructed reach to support a fish community typical of a relatively undisturbed stream within Illinois, and difference in fish IBI value among the undisturbed upstream reach and the reconstructed site was not of sufficient magnitude to indicate a meaningful spatial difference in fish community health or integrity.
- Fish IBI values for Bonnie Creek in 1997 indicated fish community health and integrity in the reconstructed reach was equivalent to the fish community health and integrity of the undisturbed upstream site BCA. The comparison to Bonnie Creek fish IBI results would also indicate the reconstructed reach of Bonnie Creek supports a fish community typical of a relatively undisturbed stream within Illinois.

The benthic macroinvertebrate assemblage at all sites included species common to small streams in Illinois and represented most of the major groups of aquatic insects as well as snails,

aquatic isopods and amphipods, flat worms, mussels and clams. Conclusions based on the evaluation of richness based comparisons using the EPT richness and total richness metrics, and comparison using MIBI values include the following:

- Overall abundance (number of specimens) of benthic macroinvertebrate organisms in the samples collected, including the regional reference location may be an artifact of differences in sampling effort. Confounding factors at the time of sample collection included lack of measureable flow at many sites. However, low specimen counts were common to all sites and collection dates in this study and was not considered a significant factor in interpretation of results.
- The richness-based metrics for all stream sites were highly variable. Comparisons indicated a general, but not conclusive, trend for higher EPT richness in April samples compared to samples collected in August. In contrast, the total richness metric showed a general, but not conclusive, trend for higher richness in August than present in April. Both the EPT richness and total richness values were low and any differences in richness value were not consistent or of sufficient magnitude to be meaningful and likely could be attributed to sample collection and sample analysis variability, and the influence of the agricultural setting for the sample streams.
- The results of the August MIBI for Galum Creek indicated the reconstructed reach attained macroinvertebrate community recovery that reflects normal in-stream conditions (as depicted by MIBI values for the undisturbed upstream site). MIBI results also indicated the Galum Creek macroinvertebrate assemblage was equivalent to a reference site considered minimally impacted by mining activities. Results of the MIBI evaluation suggest the recovery of the macroinvertebrate community in Galum Creek occurred within a 5-year time span.
- MIBI results for samples collected from the reconstructed portion of Bonnie Creek in 1997 indicated recovery to a level equivalent with MIBI values from the undisturbed upstream reach of Bonnie Creek. Total richness and EPT richness values at the upstream, relocated reach, and downstream monitoring sites were relatively consistent for the 1997, 2003, and 2006 monitoring periods in Bonnie Creek and suggested the normal condition of the benthic macroinvertebrate community in Bonnie Creek may be typical of streams in agricultural settings and slightly lower than determined for the un-impacted regional reference site selected.

5 References

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Tables

TABLE 1. ILLINOIS STREAM MONITORING SITE SUMMARY TABLE

Stream	Site	Lat.	Long.	County
Galum	GLA	38.0854833	-89.555033	Perry
	GLC	38.0575833	-89.5559	Perry
	GLD	38.0473833	-89.521	Perry
Bonnie	BCA	38.0865667	-89.514617	Perry
	BCB2	38.0821667	-89.514617	Perry
	BCB3	38.0648667	-89.520017	Perry
	BCB4	38.0559333	-89.524867	Perry
	BG	38.0494333	-89.5226	Perry
White Walnut	WWA	38.121	-89.306	Perry
	WWC2	38.113	-89.326	Perry
	WWD	38.109	-89.348	Perry
Eagle Creek Basin	ATE-06	37.62889	-89.326	Saline

TABLE 2. APRIL-MAY FISH INDEX OF BIOLOGICAL INTEGRITY METRIC VALUES AND METRIC SCORES FOR RECONSTRUCTED STREAMS IN PERRY COUNTY, ILLINOIS AND A REFERENCE SITE IN THE EAGLE CREEK BASIN

IBI Metric	Eagle Creek ATE-06 20-Oct-86	Bonnie Creek BCA	BCC Apr-97	BCD	Galum Creek GLA	GLC Apr-98	GLD	Galum Creek GLA	GLC May-93	GLD	Galum Creek GLA	GLC Apr-97	GLD
Metric Values													
Total Number of Species[1]	7	8	9	4	7	6	12	14	8	12	7	5	8
Number of Darter Species[2]	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Sunfish Species[3]	4	3	2	2	4	2	3	4	4	3	3	3	3
Number of Sucker Species[3]	0	0	0	0	0	1	0	1	0	0	0	0	0
Number of Sensitive Species[4]	1	3	1	1	1	2	4	3	1	3	2	1	2
% Tolerant Individuals[3]	95	46.6	38.2	43.5	24.4	2.0	40.0	45.5	37.9	41.8	17.2	42.2	26.9
% Omnivores[3,8]	37	14.7	2.2	0	0	0	3.3	28.4	0	10.1	12.1	1.6	15.3
% Insectivores[3,8]	53	85.3	97.4	100	92.7	98.0	94.4	67.0	75.9	86.1	87.9	98.4	84.7
% Carnivores[3,8]	11	0	0	0	7.3	2.0	2.2	3.4	24.1	38.0	0	0	26.3
Catch per Unit Effort[5]	unknown												
% Simple Lithophils[3,8]	0	0	1.8	0	0	0	3.3	0	0	1.3	0	0	1.9
% DELT Anomolies[5,8]	0												
Number of Minnow Species[6]	2	4	6	2	0	0	3	4	0	5	3	1	5
% Pioneer Species[7,8]	37.0	16.4	7.0	32.3	19.5	0	33.3	34.1	24.1	38.0	17.2	42.2	26.3
% Darter, Madtom, Sculpin[2]	0	0	0	0	0	0	0	0	0	0	0	0	0
Metric Scores													
Total Number of Species[1]	3	3	3	1	1	1	3	5	3	3	1	1	3
Number of Darter Species[2]	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Sunfish Species[3]	5	3	3	2	5	3	3	5	5	3	3	3	3
Number of Sucker Species[3]	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Sensitive Species[4]	1	3	1	1	1	1	3	3	1	3	1	1	1
% Tolerant Individuals[3]	1	3	3	3	5	5	3	3	3	3	5	3	3
% Omnivores[3,8]	1	5	5	5	1	5	5	3	1	5	5	5	5
% Insectivores[3,8]	1	5	5	5	1	5	5	5	1	5	5	5	5
% Carnivores[3,8]	1	1	1	1	3	1	1	1	5	1	1	1	1
Catch per Unit Effort[5]	3	3	3	3	3	3	3	3	3	3	3	3	3
% Simple Lithophils[3,8]	1	1	1	1	1	1	1	1	1	1	1	1	1
% DELT Anomolies[5,8]	5	3	3	3	1	3	3	3	1	3	3	3	3
Fish IBI score	24	32	30	27	24	30	32	34	26	32	30	28	30
Flow (cfs)		9.8	6.3	15.9	*	<1	1	13	25	31	9	16	18
Number of Minnow Species[6]	1	3	3	1	1	1	3	3	1	3	1	1	3
% Pioneer Species[7,8]	1	5	5	3	1	5	3	3	1	3	5	3	3
% Darter, Madtom, Sculpin[2]	1	1	1	1	1	1	1	1	1	1	1	1	1

1 Figure 5 in Simon and Dufour 1998
2 Figure 6 in Simon and Dufour 1998
3 Table 3 in Simon and Dufour 1998
4 Figure 11 in Simon and Dufour 1998
5 Unknown. Assume middle value for catch per unit effort, and no deformities for all sites.
6 Figure 9 in Simon and Dufour 1998
7 Table 2 in Simon and Dufour 1998
8 May be adjusted for low number of fish captured

TABLE 3. AUGUST FISH INDEX OF BIOLOGICAL INTEGRITY METRIC VALUES AND METRIC SCORES FOR RECONSTRUCTED STREAMS IN PERRY COUNTY, ILLINOIS AND A REFERENCE SITE IN THE EAGLE CREEK BASIN

IBI Metric	Eagle Creek ATE-06 20-Oct-86	Bonnie Creek BCA	BCC Aug-97	BCD	Galum Creek GLA	GLC Aug-88	GLD	Galum Creek GLA	GLC Aug-93	GLD	Galum Creek GLA	GLC Aug-97	GLD
Metric Values													
Total Number of Species[1]	7	12	6	4	12	7	10	10	9	7	9	9	13
Number of Darter Species[2]	0	0	0	0	0	0	0	0	0	0	1	0	0
Number of Sunfish Species[3]	4	3	1	3	4	2	3	4	2	2	3	3	3
Number of Sucker Species[3]	0	0	0	0	2	0	0	1	0	0	0	0	0
Number of Sensitive Species[4]	1	2	1	1	1	2	2	2	1	1	2	2	3
% Tolerant Individuals[3]	95	63.6	20.9	88.3	13.7	4.7	7.7	34.1	50	44.9	19.6	48.6	32.7
% Omnivores[3,8]	37	29.0	0.0	0.0	3.9	4.7	1.5	9.8	26.3	5.1	0	0	12.3
% Insectivores[3,8]	53	68.5	100	95.0	92.2	81.4	93.8	87.8	68.4	94.4	92.8	89.2	75.9
% Carnivores[3,8]	11	1.9	0.0	5.0	2	14	4.6	0.0	5.3	0	7.2	10.8	11.7
Catch per Unit Effort[5]	unknown												
% Simple Lithophils[3,8]	0	3.1	6.0	0	5.9	0	0	2.4	0	1	1	0	11.7
% DELT Anomolies[5,8]	0												
Number of Minnow Species[6]	2	6	4	0	2	2	2	2	1	4	1	1	5
% Pioneer Species[7,8]	37	49.4	0	88.3	9.8	0	3.1	24.4	18.4	40.8	17.5	35.1	31.5
% Darter, Madtom, Sculpin[2]	0	0	0	0	0	0	0	0	0	0	5.2	0	0
Metric Scores													
Total Number of Species[1]	3	3	1	1	3	1	3	3	3	3	3	3	5
Number of Darter Species[2]	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Sunfish Species[3]	5	3	1	3	5	3	3	5	3	3	3	3	3
Number of Sucker Species[3]	1	1	1	1	3	1	1	1	1	1	1	1	1
Number of Sensitive Species[4]	1	1	1	1	1	1	1	1	1	1	1	1	3
% Tolerant Individuals[3]	1	1	5	1	5	5	5	3	3	3	5	3	3
% Omnivores[3,8]	1	3	5	5	5	1	5	1	1	5	5	1	5
% Insectivores[3,8]	1	5	5	5	5	1	5	1	1	5	5	1	5
% Carnivores[3,8]	1	1	1	3	1	5	1	1	3	1	3	5	5
Catch per Unit Effort[5]	3	3	3	3	3	3	3	3	3	3	3	3	3
% Simple Lithophils[3,8]	1	1	1	1	1	1	1	1	1	1	1	1	1
% DELT Anomolies[5,8]	5	3	3	3	3	1	3	1	1	3	3	1	3
Fish IBI score	24	26	28	28	36	24	32	22	22	30	34	24	38
Flow (cfs)		0	0	2.8	**	**	<1	*	1	2	**	***	***
Number of Minnow Species[6]	1	3	3	1	1	1	1	1	1	3	1	1	3
% Pioneer Species[7,8]	1	3	5	1	5	1	5	1	1	3	5	1	3
% Darter, Madtom, Sculpin[2]	1	1	1	1	1	1	1	1	1	1	1	1	1

1 Figure 5 in Simon and Dufour 1998
2 Figure 6 in Simon and Dufour 1998
3 Table 3 in Simon and Dufour 1998
4 Figure 11 in Simon and Dufour 1998
5 Unknown. Assume middle value for catch per unit effort, and no deformities for all sites.
6 Figure 9 in Simon and Dufour 1998
7 Table 2 in Simon and Dufour 1998
8 May be adjusted for low number of fish captured

TABLE 4. BENTHIC MACROINVERTEBRATE RICHNESS VALUES SUMMARY FOR RECONSTRUCTED STREAMS IN PERRY COUNTY, ILLINOIS.

Site	Bonnie Creek					
	Spring			Fall		
	Apr-97	Apr-03	Apr-06	Aug-97	Aug-03	Aug-06
EPT Richness						
BCA	9	3	5	2	2	2
BCC	6	1[a]	5[a]	2	2[a]	3[a]
BCD	7	0	1	na	1	1
Total Richness						
BCA	15	10	16	15	14	11
BCC	13	6[a]	16[a]	12	11[a]	14[a]
BCD	13	7	13	na	12	10

Site	White Walnut Creek	
	Apr-03	Aug-03
EPT Richness		
WWA	5	0
WWC	5	2
WWD	3	3
Total Richness		
WWA	13	7
WWC	15	10
WWD	13	16

Site	Galum Creek									
	Spring					Fall				
	Apr-88	Apr-93	Apr-97	Apr-03	Apr-06	Aug-88	Aug-93	Aug-97	Aug-03	Aug-06
EPT Richness										
GLA	1	5	6	1	5	1	2	5	3	3
GLC	1	2	2	1[a]	3[a]	3	2	1	2[a]	1[a]
GLD	4	2	5	0	4	4	5	1	2	2
Total Richness										
GLA	7	14	13	9	17	15	13	19	11	14
GLC	3	8	7	7[a]	17[a]	15	14	14	14[a]	18[a]
GLD	10	7	11	8	19	19	12	12	14	27

1. "a" indicates number of different taxa from multiple monitoring sites sampled in 2003 and 2006 in the reconstructed reach.

TABLE 5. APRIL-MAY BENTHIC MACROINVERTEBRATE INDEX OF BIOLOGICAL INTEGRITY (MIBI) METRIC VALUES AND METRIC SCORES FOR RECONSTRUCTED STREAMS IN PERRY COUNTY, ILLINOIS AND A REFERENCE SITE IN THE EAGLE CREEK BASIN

MIBI Metric	Eagle Creek	Bonnie Creek			Galum Creek			Galum Creek			Galum Creek		
	ATE-06	BCA	BCC	BCD	GLA	GLC	GLD	GLA	GLC	GLD	GLA	GLC	GLD
	20-Oct-86		Apr-97			Apr-88			May-93			Apr-97	
Flow (cfs)		9.8	6.3	15.9	NA	1.0	1.0	12.7	24.9	0.85	8.9	15.7	18.1
Conductivity (umhos/cm)		523	694	3050	1100	2200	4100	477	1289	1305	562	1510	1470
Metric Values													
Taxa richness	10	15	13	13	7	3	10	14	8	7	13	7	11
Hilsenhoff Biotic Index	7.0	4.6	5.7	5.4	5.9	5.5	5.7	6.2	6.7	4.9	6.0	5.8	5.3
Scrapers:filt/collectors	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
EPT: chironomid	1.6	5.4	4.7	0.8	0.0	1.0	1.1	0.0	3.3	34.0	1.7	0.0	2.5
% Dominant Taxa	27.2	26.8	46.3	48.0	37.5	50.0	40.9	41.0	24.1	58.1	30.2	41.9	27.7
EPT richness	2	9	6	7	1	1	4	5	2	2	6	2	5
Community Loss	reference	0.53	0.69	0.76	1.50	3.00	0.80	0.43	1.10	1.20	0.62	1.10	0.81
Shredders:Total	0.00	0.04	0.01	0.07	0.00	0.00	0.18	0.05	0.00	0.67	0.00	0.00	0.13
Metric Scores													
Taxa richness	6	6	6	6	4	0	6	6	4	4	6	4	6
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	6	6	6	6	6	6
Scrapers:filt/collectors	6	2	0	0	0	0	0	0	0	0	0	0	2
EPT: chironomid	6	6	6	4	0	4	4	0	6	6	6	0	6
% Dominant Taxa	6	4	0	0	2	0	0	0	4	0	2	0	4
EPT richness	6	6	6	6	0	0	6	6	6	6	6	6	6
Community Loss	6	4	4	4	4	2	4	6	4	4	4	4	4
Shredders:Total	0	6	6	6	6	6	6	6	6	6	6	6	6
MIBI SCORE	42	40	34	32	22	18	32	30	36	32	36	26	40
Percent of Reference		95.2	81.0 *	76.2	52.4	42.9 *	76.2	71.4	85.7	76.2	85.7	61.9 *	95.2

* Score <83% and indicates reconstructed reach has lower biotic integrity than reference condition.

TABLE 6. AUGUST BENTHIC MACROINVERTEBRATE INDEX OF BIOLOGICAL INTEGRITY (MIBI) METRIC VALUES AND METRIC SCORES FOR RECONSTRUCTED STREAMS IN PERRY COUNTY, ILLINOIS AND A REFERENCE SITE IN THE EAGLE CREEK BASIN.

MIBI Metric	Eagle Creek	Bonnie Creek			Galum Creek			Galum Creek			Galum Creek		
	ATE-06	BCA	BCC	BCD	GLA	GLC	GLD	GLA	GLC	GLD	GLA	GLC	GLD
	20-Oct-86		Aug-97			Aug-88			Aug-93			Aug-97	
Flow (cfs)		<1.0	<1.0	2.0	<1	<1.0	1.0	<1.0	0.85	2.0	<1.0	<1.0	<1.0
Conductivity (umhos/cm)		620	1350	4780	395	3150	4050	597	2080	2190	720	2480	2630
Metric Values													
Taxa richness	10	15	12	NA	15	15	19	13	14	11	19	14	12
Hilsenhoff Biotic Index	7.0	7.3	6.1	NA	7.5	6.8	6.3	6.6	6.5	5.5	6.0	5.9	5.2
Scrapers:filt/collectors	0.4	0.0	0.0	NA	0.0	0.0	0.1	0.0	0.0	0.1	4.0	2.0	0.0
EPT: chironomid	1.6	2.1	3.1	NA	0.9	5.0	0.4	3.0	12.0	3.1	0.5	1.0	27.8
% Dominant Taxa	27.2	41.7	43.5	NA	38.8	43.9	52.0	18.4	26.8	32.3	33.3	24.2	69.8
EPT richness	2	2	2	NA	1	3	5	2	2	5	5	1	1
Community Loss	reference	0.47	0.58	NA	0.53	0.47	0.37	0.62	0.57	0.81	0.42	0.64	0.66
Shredders:Total	0.00	0.00	0.00	NA	0.01	0.00	0.00	0.00	0.00	0.15	0.04	0.00	0.00
Metric Scores													
Taxa richness	6	6	6	NA	6	6	6	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	6	6	NA	6	6	6	6	6	6	6	6	6
Scrapers:filt/collectors	6	0	0	NA	0	0	0	0	0	2	6	6	0
EPT: chironomid	6	6	6	NA	4	6	2	6	6	6	2	2	6
% Dominant Taxa	6	0	0	NA	2	0	0	6	4	2	2	2	0
EPT richness	6	6	6	NA	0	6	6	6	6	6	6	6	0
Community Loss	6	6	4	NA	4	6	6	4	4	4	6	6	4
Shredders:Total	0	6	6	NA	6	6	6	6	6	6	6	6	6
MIBI SCORE	42	36	34	NA	28	36	32	40	38	38	40	40	28
Percent of Reference		85.7	81.0 *	NA	66.7	85.7	76.2	95.2	90.5	90.5	95.2	95.2	66.7

* Score <83% and indicates reconstructed reach has lower biotic integrity than reference condition.

Figures

FIGURE 1. View of Regional Reference Site ATE-06 in the Eagle Creek Basin, Saline County, Illinois.

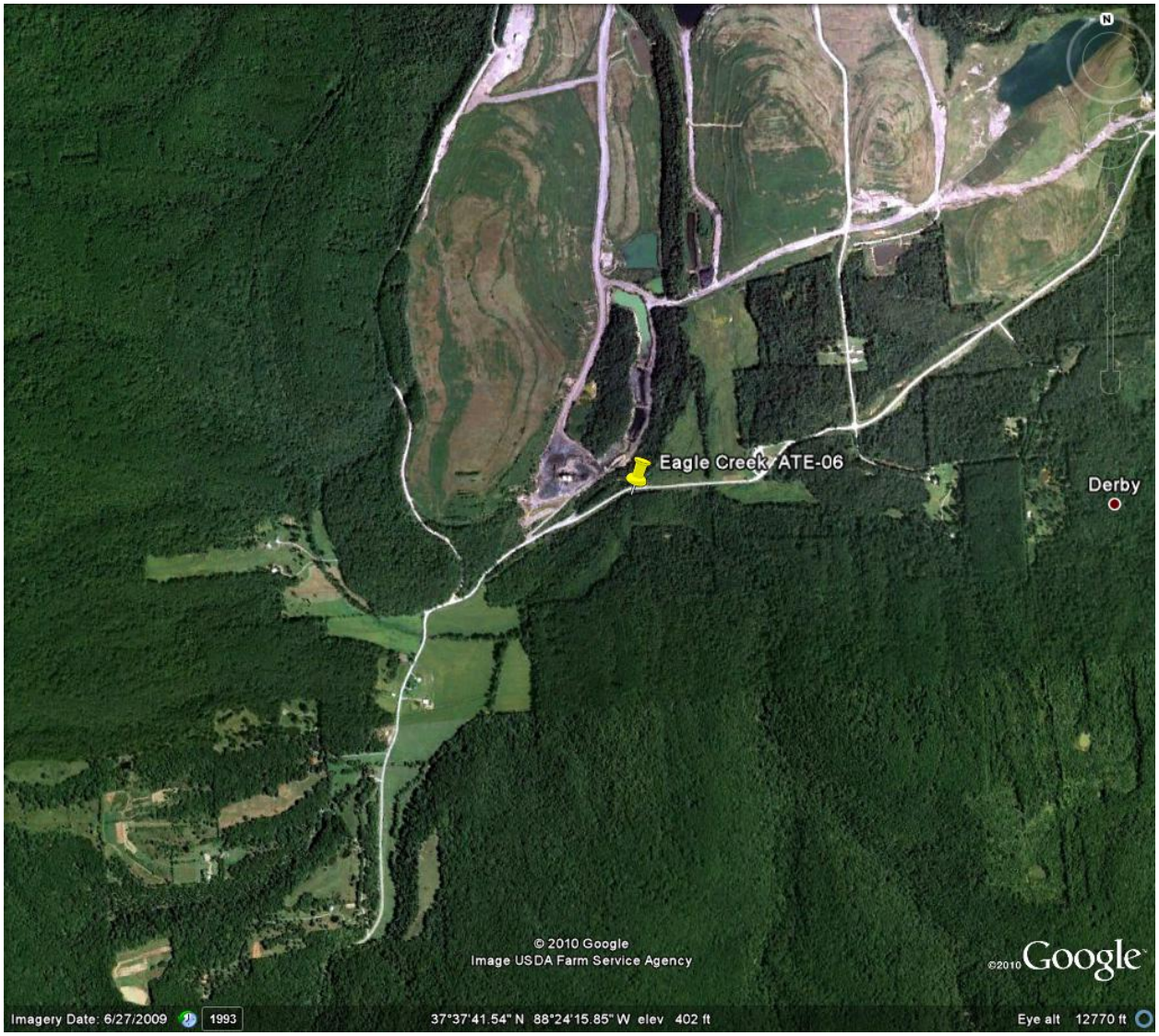

FIGURE 2. View of Galum and Bonnie Creek Monitoring Sites, Perry County, Illinois.

FIGURE 3. View of White Walnut Creek Monitoring Sites, Perry County, Illinois.